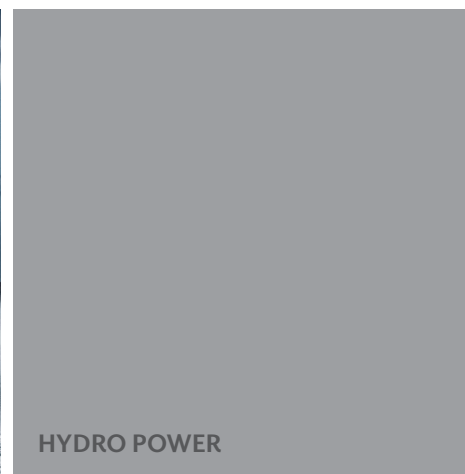


VERIFICATION OF RUN-OFF DATA FROM THREE SWEDISH CATCHMENTS COMPARING ECMWF AND WTM

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Verification of run-off data from three Swedish catchments comparing ECMWF and WTM

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Foreword

The WTM (Weather Terrain Model) has previously shown some improvement in temperature and precipitation forecasts compared to EC (European Centre) for observation stations. The basis for the analysis in this project was to see if those improvements could be recreated in runoff-predictions.

Due to certain circumstances the comparison between the two models were not considered relevant.

The report was prepared by Bjørge Jansen, senior meteorologist at StormGeo the benefit of HUVA - Energiforsk's working group for hydrological development. HUVA incorporates R&D-projects, surveys, education, seminars and standardization. The following are delegates in the HUVA-group:

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Stockholm, November 2015



Cristian Andersson

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Sammanfattning

I projektet har en analys genomförts där tillrinningsprognoser baserade på två olika meteorologiska modeller, EC (European Centre) och WTM (Weather Terrain Model), jämförs för tre olika avrinningsområden.

De meteorologiska prognoserna har utgjort input till en hydrologisk modell (HBV-modell) för att studera skillnaderna i tillrinningsprognosen. Resultatet har jämförts med mätdata.

WTM har visat på förbättringar för temperatur- och nederbördsprognoser jämfört med EC-modellen vid jämförelser med nederbördsstationer. Utgångspunkten för analysen var att se om dessa förbättringar kan återspeglas i förbättrade tillrinningsprognoser.

Analysen visar att både EC och WTM generellt ger för låg tillrinning i Kultsjön och Ottsjön och att avvikelsen är något större i WTM. För Burvattnet är det tvärtom, både EC och WTM ger något för mycket tillrinning.

Studien visar att avvikelserna till största del beror på kalibreringen ("Pcorr") i HBV-modellen. Den är anpassad till en annan meteorologisk modell, vilket verkar vara skälet för mycket av avvikelsen mellan prognoser och observationer. Utan denna kalibrering, verkar det som att tillrinningen i både EC och WTM skulle ha landat närmare observerad tillrinning.

Jämförelser mellan modellerna är som konsekvens av detta inte relevant. Eventuell framtida liknande utvärdering måste ta hänsyn till den hydrologiska modellens kalibrering. En sådan analys kan också göras mer intressant genom att använda en mer sofistikerad hydrologisk modell och genom att välja avrinningsområde där den verkliga topografin avviker mer från topografin i vädermodellen.

Summary

In this project an analysis have been performed, where the prognoses of runoff from two models, EC (European Centre) and WTM (Weather Terrain Model), are compared for three Swedish catchments. The runoff prognoses are run through a HBV-model. WTM has shown some improvement in temperature and precipitation forecasts compared to EC for observation stations, and the basis for the analysis are to see if those improvements can be recreated in runoff-predictions.

The analysis shows that both EC and WTM in general have too low runoff for two catchments, Kultsjön and Ottsjön, and this bias is slightly larger in WTM. For Burvattnet it is the other way around, EC and WTM has slightly too much runoff. It is shown that the deviations is largely due to the calibration ("Pcorr") in the HBV-model. Calibration of the HBV-model is adapted to another model, which seems to be the reason for much of the deviation between prognoses and observed runoff. Without this calibration, it seems like runoff in both EC and WTM would have been closer to the observed.

Comparison between the two models is, as a consequence of this, not relevant. Future similar test will need to address this issue. There is also potential in improving the analysis by using a more sophisticated HBV-model and in choosing catchments where the real topography differ more from the topography in the weather-model.

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1 Introduction

In this project, we analyse the potential of reducing the error in runoff prediction from three Swedish catchments by using a statistical calibrated weather prognosis.

One of the best and most used weather models used in runoff prediction is the ECMWF-model (often referred to as "EC"). Verification studies of temperature and precipitation shows that the ECMWF-model is best, or among the best models (figure 2). Some fine scale resolution models (e.g. Hirlam, Arome) show better results in some circumstances (Roberts, Lean, 2008), but the remaining error in ECMWF is to a larger degree a systematic error, which is better suited for a statistical calibration than the fine resolution models.

StormGeo have developed such a statistical calibration for temperature and precipitation, based on the ECMWF-model, the WTM-model (Weather Terrain Model).

The project aims to investigate the extent to which systematic errors in temperature and precipitation forecasts (which are used as input to hydrologic models) can be reduced by using the WTM-model. This is done by comparing the measured inflow with estimated inflow from WTM- and "raw" EC-forecasts, used as input to a hydrological model.

The project is financed by Elforsk through the HUVA-program (Hydrologiskt UtvecklingsArbete inom vattenkraftindustrin). The execution of the project has been done as cooperation between StormGeo and Vattenregleringsföretagen. StormGeo has provided daily forecasts of temperature and precipitation and Vattenregleringsföretagen has run the HBV-models, and together with observed values, provided all data for StormGeo, which has performed the analysis.

In consultation with Vattenregleringsföretagen, we have chosen three catchments for this study. The criteria of the choice has been to have good measurement data of inflow, rapid response of the precipitation so the weather forecast means relatively more than the quality of the hydrological model for the runoff, and a presence of hilly terrain and mountains. A large part of the calibration done by the WTM-model is due to complex terrain.

To further isolate the weather in the analysis of runoff, we have chosen late summer and early autumn as verification period, with insignificant snow either on the ground or as precipitation.

This study will look into daily runoff, but also episodes of precipitation and runoff, which aggregates values over several days, which in some cases can be more relevant.



Figure 1 The areas chosen for this study.

2 Data

2.1 ECMWF-MODEL

The European Centre for Medium-Range Weather Forecasts (ECMWF) is an independent international organization supported by 26 European States. For many years the ECMWF has produced the best global deterministic atmospheric forecasts in the world (WMO lead centre for deterministic forecast verification). The principal objective of the ECMWF (<http://www.ecmwf.int/>) is to continuously improve global medium range weather forecasting products with a particular emphasis on early warnings of severe weather.

The centre uses highly advanced numerical weather prediction (NWP), to forecast the weather from its present measured state. Its complex calculations require a constant input of meteorological data, including air pressure, temperature, wind speed and direction, and humidity. This information is collected by satellites and other observing systems such as automatic and manned stations, aircraft, ships and weather balloons. These observations are assimilated into the forecasting model to produce medium-range forecasts, predicting the weather up to 15 days ahead. These forecasts are documented to be the best global forecasts in the world, mainly due to advanced assimilation systems (incorporation of observations into its analysis), advanced model dynamics and physics parameterizations and higher horizontal and vertical resolution than its competitors (NCEP – USA and UK Met Office amongst others).

Some finer resolution model might verify better in some parameters in some circumstances, but has some other disadvantages. The fine resolution models will often bring larger errors when the scale of the precipitation area is below a given value which the models are unable to predict. This happens especially in convective (shower) situations.

A forecast over Europe is today typically reliable for at least a week forward in time compared to 4-5 days in 1980.

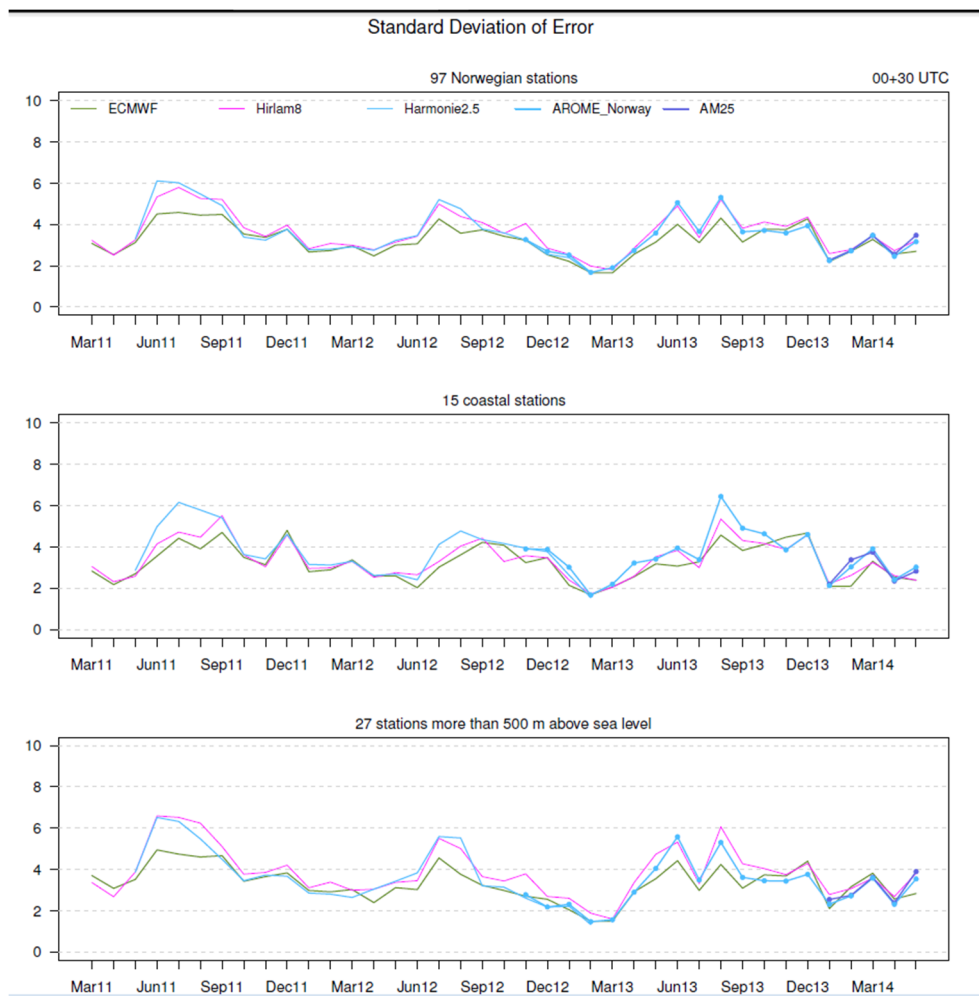


Figure 2 Verification of precipitation for the first day of the prognosis, for recent years for EC and some other models with finer scale resolution showing the standard deviation of error after removing bias (<http://met.no>).

2.2 WTM -MODEL

Weather Terrain Model (WTM) is based on the ECMWF-model. It reduces the systematic errors in temperature and precipitation mainly by taking into consideration the topography around the point of interest and other characteristics as proximity to sea and how this affects the temperature and precipitation in different kinds of weather regimes.

The model is the result of a scientific project financed by the Norwegian Railsystem, Norways directory of Roads ,NGI Norwegian Geotechnical Institute, Agder Energi, E-CO and Statkraft.

The purpose of WTM is to improve the prognosis of precipitation and temperature of the ECMWF IFS model (EC model) especially for use as indata into hydrological models. WTM has a fine resolution horizontal grid, 1 x 1 km, to more realistically better catch topographic effects, than the much coarser EC model (16*16 km). The calibration is done to generally calibrate the ECMWF-model, so that every point may be calibrated, without the use of observations.

The calibration period used approximately 90,000 precipitation observations and 130,000 temperature observations in Norway and Sweden. Verifications have shown reduced mean absolute error in both precipitation and temperature of about 10%. Best results were accomplished for large precipitation amounts in complicated terrain. This is probably because there is a larger systematic error when exposed to this terrain. Temperature has also shown better results, especially in winter and night-time.

2.3 HBV-MODEL

The runoff model is a HBV-model which is run by SMHI(<http://www.smhi.se/sgn0106/if/hydrologi/hbv.htm>). The model uses precipitation and temperature as input in one point in a catchment and is then extrapolated according to the different height zones in the catchment area.

The model also uses a correction factor on the precipitation to get the correct response of runoff from the precipitation prognosis on longer term (Pcorr). For the catchment areas in this study, the "Pcorr" is calibrated using a model unknown to StormGeo. This correction factor is made according to a precipitation model that is not either ECMWF or WTM and may have a large impact on the results. We have to take this very carefully into consideration when analyzing the data.

2.4 CATCHMENTS

2.3.1 Ottsjön

Medium large catchment, ca. 600 km². A subjective assessment of the area suggest that the mountain areas in the southeast may increase real precipitation compared to the model, but Sylarna, further away in the southwest may decrease the precipitation amounts.



Figure 3 The catchment of Ottsjön from Google Earth.

2.3.2 Burvattnet

Small catchment, ca. 100 km² with rapid response on precipitation. The topography is about the same height in all directions. This suggest that the precipitation in the weather model is more or less as observed from all wind directions.

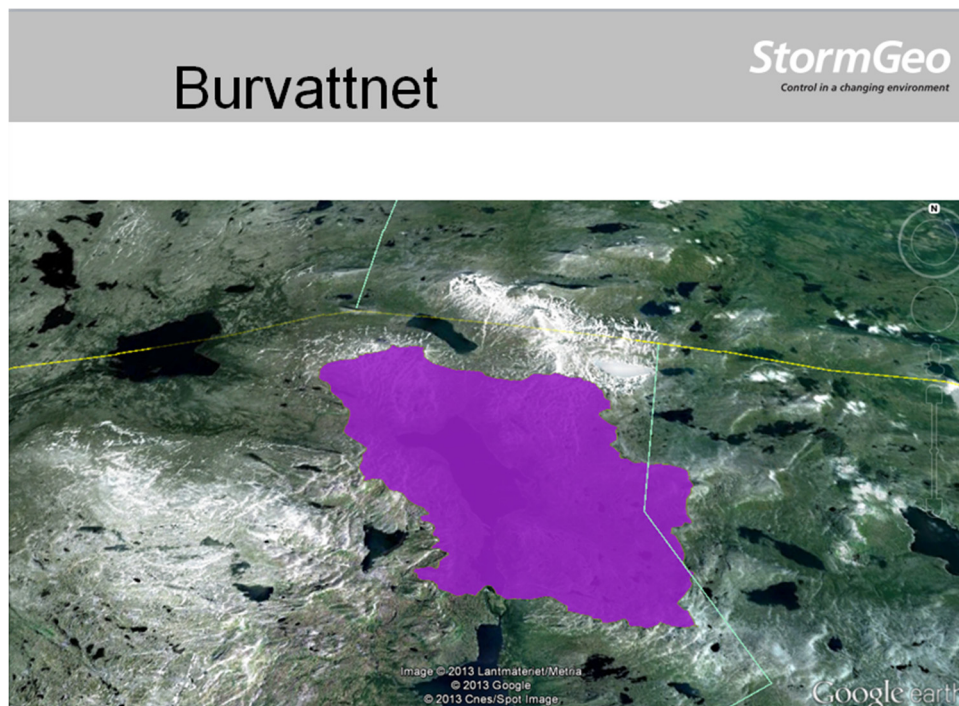


Figure 4 The catchment of Burvattnet from Google Earth.

2.3.3 Kultsjön

Relatively large catchment, stretching 60-70km east-west. The western part is inside Norway, and may get its largest precipitation amounts from westerly winds. Most of the catchments probably receive largest precipitation amounts when the wind is southeast, and passes a mountain ridge from this direction.

The HBV-model for Kultsjön was further divided into 17 subregions, each with its own temperature and precipitation prognosis. The results is however presented for the whole catchment.

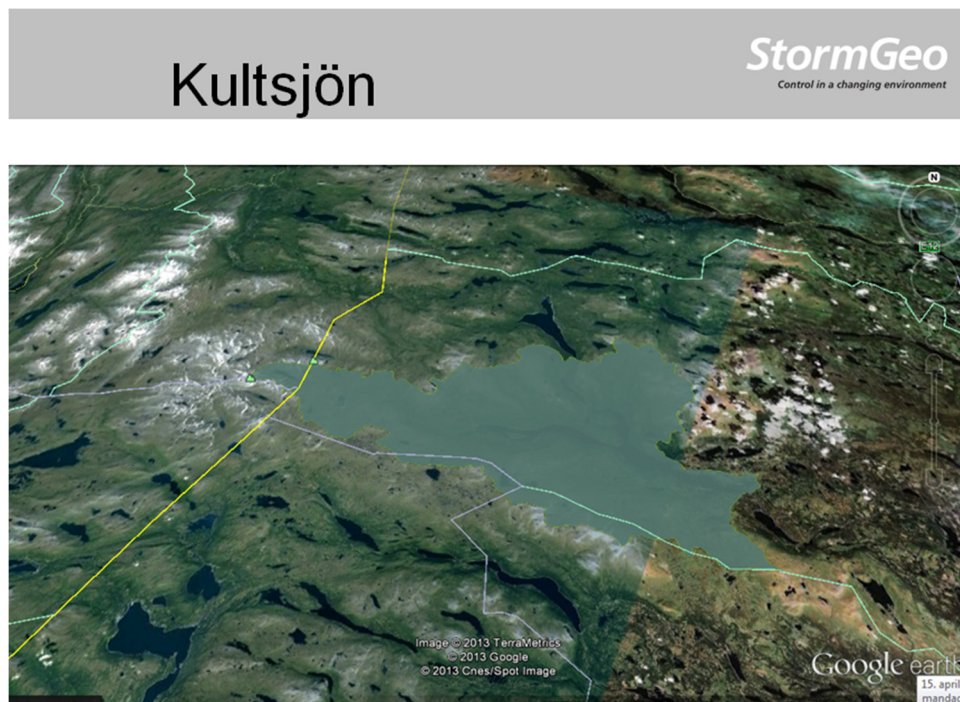


Figure 5 The catchment of Kultsjön from Google Earth.

3 Results

This analysis looks into predictions and measurements of daily precipitation and runoff. StormGeo has delivered prognosis for the next 5 days for temperature and precipitation for the 3 catchments, although this study will look most closely at the first day of the prognosis. On the first day, the error in the amounts of evaporation, ground water and other hydrological parameters are assumed to be small, but growing in time. As a consequence of this, we assume that the relative distribution of the error due to the precipitation forecast is larger the first day of the prognosis, and decreases with longer lead-time in the forecast.

First, we look at the main characteristics for all 3 catchments.

Burvattnet(Pcorr=1,05)	EC	WTM	Obs
Precipitation	3,93mm/d	3,57 mm/d	3,98 mm/d
Runoff	3,62 m³/s/d	3,52 m³/s/d	3,4 m³/s/d
Snow reservoir	0,92 mm	0,92 mm	0,92 mm
Soil water	113,4 mm	113,3 mm	112,6 mm
Evaporation	0,25 mm/d	0,24 mm/d	0,96 mm/d
Uz	3,82 mm	3,63 mm	3,84 mm
Lz	90,3 mm	90,3 mm	90,3 mm
Correlation	EC,obs	WTM,obs	EC,WTM
Prec 24hr	0,879	0,876	0,996
Runoff	0,959	0,954	0,997

Ottsjön (Pcorr=0,82477)	EC	WTM	Obs
Precipitation	2,12 mm/d	2,07 mm/d	2,52 mm/d
Runoff	14,68 m³/s/d	14,65 m³/s/d	14,89 m³/s/d
Snow reservoir	0,56 mm	0,59 mm	0,45 mm
Soil water	104,1 mm	104,1 mm	103,6 mm
Evaporation	0,16 mm/d	0,15 mm/d	0,82 mm/d
Uz	1,28 mm	1,24 mm	1,53 mm
Lz	21,5 mm	21,5 mm	21,6 mm
Correlation	EC,obs	WTM,obs	EC,WTM
Prec 24hr	0,833	0,836	0,999
Runoff	0,992	0,991	1

Kultsjön (Pcorr=0,90231)	EC	WTM	Obs
Precipitation	3,11 mm/d	2,94 mm/d	3,44 mm/d
Runoff	31,5 m ³ /s/d	31,1 m ³ /s/d	32 m ³ /s/d
Snow reservoir	0,22 mm	0,24 mm	0,32 mm
Soil water	99,8 mm	99,8 mm	99,3 mm
Evaporation 24hr	0,16 mm/d	0,15 mm/d	0,75 mm/d
Uz	4,12 mm	4,03 mm	4,31 mm
Lz	32,3 mm	32,3 mm	32,3 mm
Correlation	EC,obs	WTM,obs	EC,WTM
Prec 24hr	0,896	0,894	0,999
Runoff	0,988	0,989	1

Table 1 Mean values for different parameters. Uz and Lz is upper and lower ground water. Correlations between EC, WTM and “observed” values on a daily resolution.

We see that the evaporation in the model is far too low. This is because there is a bug somewhere in the system with too low temperature, which gives less evaporation. This affects the total runoff, but not so much the comparison between the models, as the bug is the same in both models. This does not seem to give any errors due to snow accumulation.

For all 3 catchments both ECMWF and WTM give less precipitation than “observed”. The “observed” precipitation amount needs a “Pcorr” to release the correct amount of runoff in longer term, so this means that the “observed” value is somewhat too high for Ottsjön (Pcorr=0,82) and Kultsjön (Pcorr=0,90). In these catchments the EC and WTM looks like they would have been better off not using the Pcorr, which gives too low precipitation and thereby too low runoff. Too low runoff is despite too low evaporation.

The situation is reverse for Burvattnet which also have a Pcorr above 1 (1,05). Both EC and WTM should therefore probably have a Pcorr closer to 1 for all 3 catchments, which reflects a prognosed precipitation amount closer to reality. The errors originating from the calibration performed by Pcorr, seems to permeate this analysis.

WTM has slightly less precipitation than ECMWF because the model suggests that real topography should give less precipitation than the model topography in ECMWF. WTM catches discrepancies between the model topography in ECMWF and the real topography which in turn affects the precipitation amounts. It seems nevertheless that WTM do not change the amounts in ECMWF too much. The correlation for Burvattnet is 0,996. For Burvattnet this is probably due to small differences in model height and real height (see figure 6). Burvattnet (~100km²) has a mean height of 771 m.a.s. in WTM, and as we see on the map, this is approximately the same height in the ECMWF model.

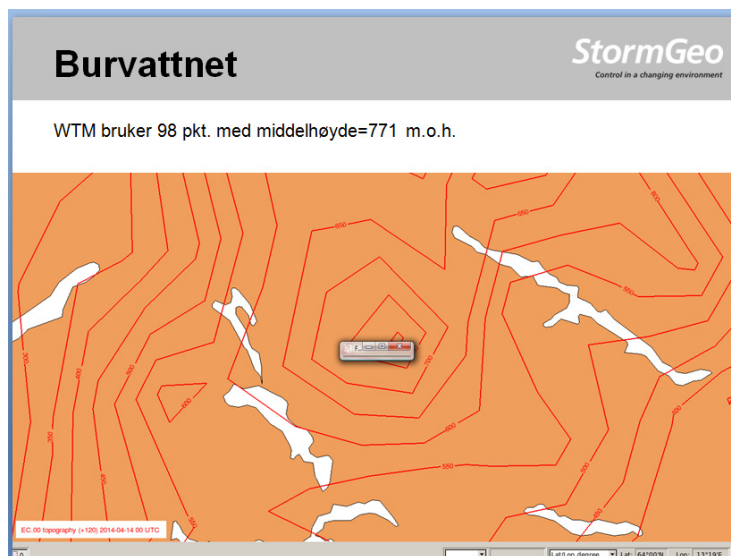


Figure 6 Topographic heights from the ECMWF-model. The marking in the map represents the catchment area of Burvattnet.

For Ottsjön the correlation between ECMWF and WTM is even higher, at 0,999. Also here, the mean WTM height (906 m.a.s.) is about the same as ECMWF height. But this catchment is also much larger (~600 km²), which means that differences even out throughout the area.

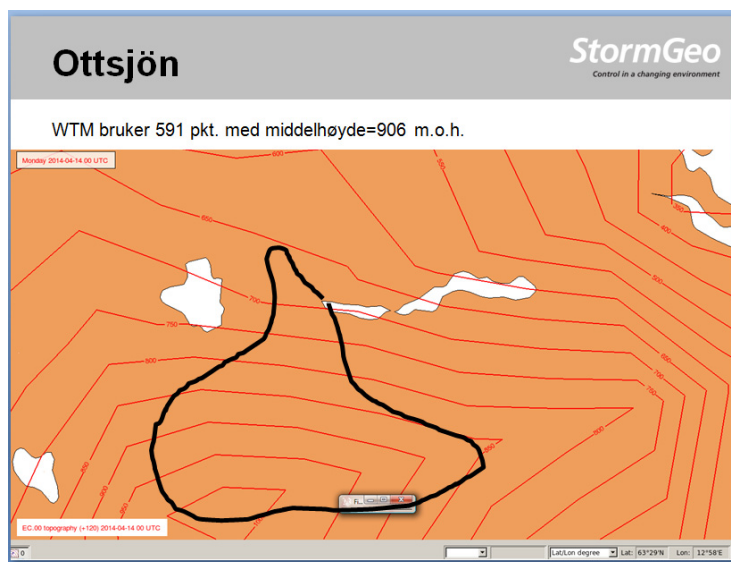


Figure 7 Topographic heights from the ECMWF-model. The black line in the map represents the catchment area of Ottsjön.

The same as for Ottsjön also applies to Kultsjön. The correlation is high (0,999), the heights are about the same, 796 m.a.s. which seem to be about the same as in the map of the model height. This area is also even larger (~950km²) than Ottsjön which evens out the differences in precipitation prognosis between WTM and EC, when accumulated over a large area.

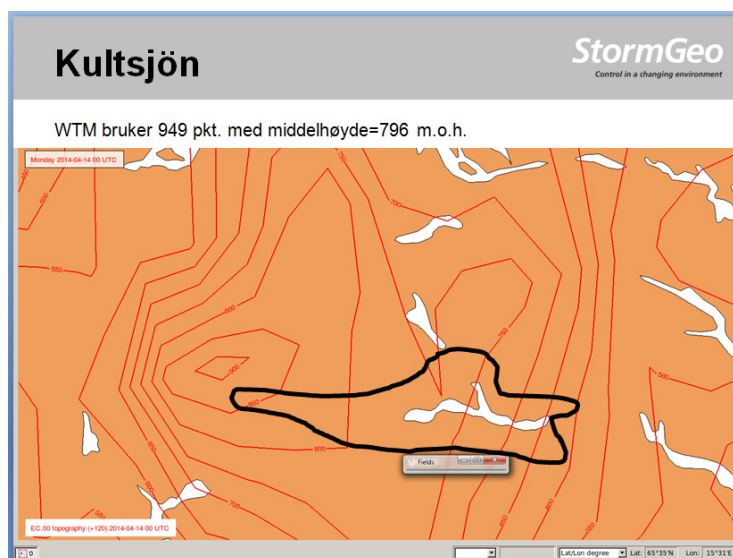


Figure 8 Topographic heights from the ECMWF-model. The black line in the map represents the catchment area of Kultsjön.

So it seems that the real topography is close to the topography of the ECMWF, and that this is not a big source of error in the precipitation prognosis.

But the “observed” amount of precipitation is also a modelled value and has uncertainty. We can although see that we probably have less precipitation in our weather model than the catchments are calibrated for. Therefore we might expect to also get less runoff, not necessarily because of wrong prediction but because of calibration. As expected, we can see that the runoff is also less than observed.

The other statistical measurements are quite equal between the ECMWF-model and WTM. The largest difference is for the mean absolute error (MAE) in precipitation and runoff-episodes. These episodes are typically the aggregate value of runoff for 5-10 days with an elevated amount of runoff. There are 5-6 episodes during the measuring period for each catchment (appendice). When looking at episodes, we overlook any phase difference, and instead look at the total amount of runoff predicted. This is in some cases more relevant than looking at the runoff for one single day.

In table 2 we see that the ECMWF has a total error of 315m³ (sum of MAE runoff for large, medium and small) distributed over 3 catchments and for the 5 next days (21,0 m³/day), and the error in WTM is insignificantly larger, at 318m³. When inspecting the mean runoff in each of these episodes, we can see that this is mainly due to bias. Both ECMWF and WTM have lower runoff than observed, probably due to calibration from the Pcorr, as discussed earlier. The runoff is even slightly smaller in WTM than EC. This is reflected in larger error in WTM in periods of larger runoff. The overall error in WTM compared to EC is maybe less than expected, taking into consideration the larger bias in precipitation and runoff.

3 catchments 5 days	EC	WTM
mean prec	-10,5 %	-16,1 % per 24hr
mean runoff	-4,2 %	-6,5 % per 24hr
corr prec	0,653	0,657 per 24hr
corr runoff	0,830	0,828 per 24hr
MAE prec	68,6 %	66,9 % per 24hr of mean obs
MAE runoff	21,4 %	21,2 % per 24hr of mean obs
MAE runoff large	146	152 total m ³ /24hr
MAE runoff medium	131	129 total m ³ /24hr
MAE runoff small	38	37 total m ³ /24hr
Mean runoff episode	-13,3%	-15,9% Over whole episode
MAE episodes	280	334 total m ³ /24hr

Table 2 Mean values, correlation and mean absolute error (MAE) for all 3 catchments and all 5 prognosis days, on a daily basis, compared to observations.

We see in table 2 that both EC and WTM have too low precipitation and too low runoff. In episodes of runoff, the deviation is even lower. A large negative prognosis of runoff for episodes is expected since these episodes have been chosen because they have large runoff, and not all of these are predicted, especially beyond the first day of the prognosis.

We want to look closer at the same statistical parameters for the first day in the prognosis. As mentioned, we assume that the first day to a larger degree reveals the systematic error in the precipitation forecast. Further out in the prognosis there can be additional sources of errors.

There is less bias for ECMWF and WTM compared to “observed” precipitation for the first day than for all 5 days, but still negative. This should give less runoff than observed, but we see that there is practically no bias in the runoff. This is probably due to the bug in the temperature, which gives too low temperature and too low evaporation as mentioned earlier. These two factors probably even each other out largely.

The results are again very similar between ECMWF and WTM. The ECMWF seems slightly better when looking at several days of larger amounts of runoff, but this seems again to be due to calibration of Pcorr, which is not calibrated exclusively for these models.

When separating the observed runoff into large, medium and small runoff, we could see that WTM generally had bigger errors than the EC-model at larger and medium amounts of runoff, but lower at small amounts of runoff. This is also consistent with a difference in bias due to calibration.

3 catchments day 1	EC	WTM
mean prec	-8,9 %	-14,2 % per 24hr
mean runoff	1,2 %	-0,3 % per 24hr
corr prec	0,869	0,869 per 24hr
corr runoff	0,981	0,979 per 24hr
MAE prec	45,2 %	44,3 % per 24hr of mean obs
MAE runoff	7,0 %	7,1 % per 24hr of mean obs
MAE runoff large	22,8	25,1 total m ³ /24hr
MAE runoff medium	34,8	33,3 total m ³ /24hr
MAE runoff small	10,3	10,3 total m ³ /24hr
Mean runoff episode	-3,4%	-4,7% Over whole episode
MAE episodes	83,6	89,1 total m ³ /24hr

Table 3 Statistics for all 3 catchments for the first prognosis day.

We can investigate this further when looking at all episodes.

There are all together 15 episodes for the 3 catchments. Summarizing all episodes, we can look at the mean runoff and MAE in all of them at the first day of the prognosis. The first column ("all") in table 4 shows that we have higher mean observed runoff than prognosed. ECMWF has 0,8m³/s less than observed and WTM has 1,1 m³/s less. This is probably the main source of error, and we can also see that WTM with larger bias, also has larger MAE.

Out of 15 episodes, there were 10 episodes with clear negative bias in the runoff in the prognosis (column 2), while 5 had about neutral bias (column 3). In these cases we see that MAE is about the same in ECMWF and WTM.

For the next days in the prognosis, day 2 to 5, we see the same pattern (not shown). All difference between ECMWF and WTM seem to be originated from the fact that a larger negative bias in WTM gives somewhat larger MAE, but that this is due to poor calibration.

Episodes runoff (m ³ /s)			all	me pos	me neutral
Day 1	mean	obs	23,3	24,1	21,6
	mean	EC	22,5	23,0	21,5
	mean	WTM	22,2	22,6	21,4
	MAE	EC	18,3	21,7	11,3
	MAE	WTM	19,3	23,3	11,1

Table 4 Statistics on the sum of episodes, mean runoff (mean) and MAE, for observed values, EC and WTM. First column is all episodes, second column is episodes with bias (less runoff in EC and WTM than observed), third column is episodes with no or negative bias.

For more details, and for each catchment, see tables in the Appendice.

It is worth noting episode 5 for Kultsjön with very large runoff. This episode was relatively well predicted for the next day, but for day 2-5 in the prognosis, the runoff

was prognosed far too low. The MAE in WTM was slightly larger than ECMWF, but again this seems to be due to calibration.

4 Conclusion

The predicted runoff from using the input from EC- and WTM-models was not very different. In most cases with larger runoff, the EC-model is better than WTM.

A source of error and probably the most important source for the difference between EC and WTM, is due to calibration (Pcorr). The models used in this study are not exclusively calibrated to return correct amount of runoff over longer term. The calibration of Pcorr is adapted to fit another model.

Another source of error is due to the temperature bug. EC and WTM have delivered too low temperature which gives too low evaporation. The error is the same in both models, so that the comparison of them is not disturbed.

The improvements from WTM has been expected to a large degree be due to different topography in the EC-model and real topography. By coincidence, the topography in the EC-model is quite close to the real topography for these 3 catchments. This should have been closer investigated when choosing the catchments for the study.

Another source of reducing the expectations of improvement is that the HBV-model is not a distributed model. WTM is expected to especially improve the amounts of prognosed precipitation with height, but the HBV-model has only a fixed extrapolation to distribute the precipitation and temperature with height. A more sophisticated HBV-model where each height zone is allowed each own temperature and precipitation prognosis, would probably utilize the benefits of the WTM-model better.

This means that the purpose of this study, to see if WTM can improve the prediction of runoff, has not been as expected. Nevertheless, this seems not to be due to the WTM model, but other factors. A new study which neutralizes these factors is still expected to show an improvement, based on the fact that WTM verifies well towards the EC-model when looking at individual observations of temperature and precipitation (WTM-report, StormGeo).

This has also been a good method of comparing results from the HBV-model. There are other factors that could be studied in the same way:

- When to utilize an ensemble weather model
- How to even out convective situations in the prognosis
- Compare other weather models, e.g. the AROME model

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Description of the HBV-model: <http://www.smhi.se/sgn0106/if/hydrologi/hbv.htm>

6 Appendices

		Burvattnet					
Episodes (all in m ³ /s)			ep1	ep2	ep3	ep4	ep5
Day 1	mean	obs	5,7	4	10,2	8,2	6
	mean	EC	5,4	4,4	8,9	7	5,6
	mean	WTM	5,4	4,2	8,3	6,7	5,4
	MAE	EC	3,4	13,5	6,9	14,2	5,1
	MAE	WTM	3,8	12,4	10	16,1	5,6
DAY 2	mean	EC	5,2	4,5	8,2	6,7	4,4
	mean	WTM	5,1	4,2	7,1	6,2	4,7
	MAE	EC	13,4	26,9	11,1	28,3	13,6
	MAE	WTM	14,1	24,9	16,3	27,3	10,7
DAY 3	mean	EC	4,3	4,5	6,5	6,7	5,3
	mean	WTM	4,1	4,1	5,7	6,1	4,9
	MAE	EC	18,7	26,5	20,7	25	9
	MAE	WTM	18,9	26,4	23	28,7	10,7
DAY 4	mean	EC	4,5	4,8	5	6,7	5,1
	mean	WTM	4,3	4,2	4,3	6,1	4,7
	MAE	EC	13,7	27,3	29,3	22,3	12
	MAE	WTM	13,4	23,2	30,1	26,8	12,7
DAY 5	mean	EC	5,1	5	4,9	7,5	6,4
	mean	WTM	5	4,3	4,2	6,7	5,8
	MAE	EC	17,3	37,5	21,8	33,4	11,1
	MAE	WTM	17,5	32,4	23	33,1	10,6

			Ottsjön			
Episodes (all in m ³ /s)			ep1	ep2	ep3	ep4
DAY 1	mean	obs	21	26,6	25,8	16,1
	mean	EC	19,4	26,3	25,2	15,8
	mean	WTM	19,4	26,2	24,9	15
	MAE	EC	7,8	13,3	3,9	5,2
	MAE	WTM	7,9	13,9	5,2	5,2
DAY 2	mean	EC	17,3	26,6	24,8	15,1
	mean	WTM	17,3	26,1	23,8	14,9
	MAE	EC	23,2	35,9	11,3	17,4
	MAE	WTM	23,7	34,9	15,9	16,2
DAY 3	mean	EC	14,2	25,9	23,6	16,5
	mean	WTM	14,2	25,4	22	16
	MAE	EC	34,9	54	26,8	20,4
	MAE	WTM	35,7	55	19,1	17,8
DAY 4	mean	EC	15	24,6	19,3	14,5
	mean	WTM	15,5	24	17,8	14,6
	MAE	EC	31,4	82,2	76,9	35,2
	MAE	WTM	33,6	84,8	70,8	34,2
DAY 5	mean	EC	16,1	21,9	11,8	13,2
	mean	WTM	16,5	21,3	11,5	13,2
	MAE	EC	26,3	83,1	60,5	14,9
	MAE	WTM	28,2	90	61,2	15,8

		Kultsjön						
Episodes (all in m ³ /s)			ep1	ep2	ep3	ep4	ep5	ep6
DAY 1	mean	obs	22,6	38,7	33,9	29,5	75	25,5
	mean	EC	22,4	37,4	31,8	29,2	73,5	25,4
	mean	WTM	22,2	37	31,6	29,1	72	25,2
	MAE	EC	15,1	51,8	35,2	6,6	83,8	8,1
	MAE	WTM	15,3	56,7	36,9	6,1	86	8
DAY 2	mean	EC	22,4	35	29,4	27,1	68,5	25,2
	mean	WTM	22,1	34,3	29,2	26,9	65,7	25,1
	MAE	EC	20,3	80,6	68,6	27,6	146	12,8
	MAE	WTM	21,6	88,3	71,3	28	166	13,9
DAY 3	mean	EC	23,5	31,3	27,1	23,7	62,8	25,4
	mean	WTM	22,9	30,6	26,9	23,5	59,3	25,1
	MAE	EC	25	156	87,2	57,1	231	10,5
	MAE	WTM	25	159	90,1	58,4	258	9,5
DAY 4	mean	EC	23,7	31,8	24,7	23,8	59,9	25,5
	mean	WTM	23	30,2	24,4	23,2	55,9	25,2
	MAE	EC	34,8	182	103,1	61,6	398	16,6
	MAE	WTM	33,3	192	104,8	64,5	419	13,3
DAY 5	mean	EC	22,1	30,7	22,8	22,3	54,5	25,2
	mean	WTM	21,5	29,1	22,5	21,9	50,9	24,9
	MAE	EC	30,8	197	118,7	63,9	571	27,1
	MAE	WTM	29,6	205	121,3	67,4	591	26

Table 5 Statistics on each episode (ep), mean runoff (mean) and MAE, for observed, EC and WTM.

Episodes			all	Positive bias	Negative bias
	mean	obs	23,3	24,1	21,6
DAY 1	mean	EC	22,5	23,0	21,5
	mean	WTM	22,2	22,6	21,4
	MAE	EC	18,3	21,7	11,3
	MAE	WTM	19,3	23,3	11,1
DAY 2	mean	EC	21,4	21,5	21,2
	mean	WTM	20,8	20,8	20,9
	MAE	EC	35,8	41,4	24,7
	MAE	WTM	38,2	45,0	24,7
DAY 3	mean	EC	20,1	19,8	20,6
	mean	WTM	19,4	19,0	20,2
	MAE	EC	53,5	63,0	34,6
	MAE	WTM	55,7	66,1	34,9
DAY 4	mean	EC	19,3	18,7	20,5
	mean	WTM	18,5	17,8	19,9
	MAE	EC	75,1	90,4	44,5
	MAE	WTM	77,1	93,7	43,8
DAY 5	mean	EC	18,0	17,3	19,3
	mean	WTM	17,3	16,5	18,8
	MAE	EC	87,6	107,2	48,5
	MAE	WTM	90,1	110,7	49,1
me Day 1-5		EC	20,2	20,0	20,6
		WTM	19,6	19,3	20,2
MAE Day 1-5		EC	270,3	323,6	163,6
		WTM	280,4	338,8	163,6

Table 6 Statistics on the sum of episodes for each day in the prognosis (day 1-5), mean runoff (mean) and mean absolute error (MAE), for observed, EC and WTM. First column is all episodes, second column is episodes with bias (less runoff in EC and WTM than observed), and third column is episodes with negative or no bias.

Specifics of episodes:

Burvattnet:

Definition: starts the day with runoff below 2 m³/s and precipitation above 5-6 mm and end at a day without precipitation and runoff back at below 2 m³/s.

episode 1=28th July to 4th August

episode 2=11th August to 21st August

episode 3=31st August to 4th September

episode 4=14th September to 24th September

episode 5=6th October to 12th October

Ottsjön:

Definition: starts the day with runoff below 16 m³/s and end at a day without runoff back at below 16 m³/s plus one more day to see if the models have the right reduction of runoff

episode 1=30th July to 3rd August

episode 2=11th August to 23rd August

episode 3=31st August to 4th September

episode 4=16th September to 20th September

Kultsjön:

Definition: starts the day with runoff above 2 m³/s and end at runoff back at below 2 m³/s.

episode 1=13th July to 21th July

episode 2=27th July to 9th August

episode 3=16th August to 25th August

episode 4=30th August to 7th September

episode 5=14th September to 28th September

episode 6=6th October to 15th October

VERIFICATION OF RUN-OFF DATA FROM THREE SWEDISH CATCHMENTS COMPARING ECMWF AND WTM

I projektet har en analys genomförts där tillrinningsprognoser baserade på två olika meteorologiska modeller, EC (European Centre) och WTM (Weather Terrain Model), jämförs för tre olika avrinningsområden.

De meteorologiska prognoserna har utgjort input till en hydrologisk modell (HBV-modell) för att studera skillnaderna i tillrinningsprognosen. Resultatet har jämförts med mätdata.

Analysen visar att både EC och WTM generellt ger avvikelser jämfört med observerad tillrinning och att den till största del beror på kalibreringen av den valda hydrologiska modellen som var anpassad till en annan meteorologisk modell.

Jämförelser mellan modellerna är som konsekvens av detta inte relevant. Eventuell framtida liknande utvärdering måste ta hänsyn till den hydrologiska modellens kalibrering.

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